

CITRUS DECLINES CAUSED BY NEMATODES. V. SLOW DECLINE.

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The first report of an association between a nematode and citrus appeared in 1889; however, it was not until 1912 when Tylenchulus semipenetrans Cobb was discovered on the roots of citrus trees in California that a nematode was found to cause a diseased condition of citrus, later called "slow decline." More than 60 years ago, Dr. N. A. Cobb predicted that the citrus nematode, as it came to be known, would someday become an important pest of citrus in Florida (1) if it were not controlled. His prediction has become a fact. Since that time surveys have shown this nematode to be a pest of citrus in all citrus-growing areas of the world. Ninety percent of groves in Texas are infested while less than 50 percent of Florida groves are infested with the nematode. California and Arizona groves have infestations of 65 and 90 percent respectively. Because this nematode does not devastate citrus trees, its presence may not be immediately detected and the damage it does may not be easily recognized. In time, however, its effect on trees will become noticeable.

Most citrus rootstocks used commercially are attacked by the citrus nematode. However, there are no obvious root symptoms to indicate the presence of this pest on nursery stock, and it often goes unnoticed, a factor which assuredly accounts for its worldwide distribution in the past. The major source of spread had been movement of infected nursery stock. Currently quarantine regulations in most areas have reduced this method of spread. A second source of infection is from replanting healthy trees in old, infested grove sites; a major problem in the citrus industry.

Soil texture greatly influences the nematode's ability to infect tree roots. Trees can become infected in almost any soil, but early infection in high numbers and subsequent population increase occurs more rapidly in fine-textured organic soils than in coarse-textured sands. Aboveground tree symptoms develop early on nematode-infected trees growing in organic or fine-textured soils, because citrus nematode penetration is favored and numbers increase rapidly. These populations damage and destroy roots early in the life of a tree, thus reducing its vigor. In contrast, aboveground symptoms may not be evident for many years on infected trees growing in deep, well drained sands, characteristic of the ridge area of central Florida. Here, the citrus nematode population increases slowly, and the root system grows at a rate about equal to the loss of infected roots. Although the root system under these conditions is more vigorous than that in organic soils, damaging populations eventually develop in time. Fruit losses from citrus nematodes in Florida may be as high as 140 boxes of fruit per acre of infected trees. Other citrus producing areas of the U.S. have reported similar, if not greater, losses from this nematode.

Life cycle: The life cycle consists of several stages, and is completed in 6 to 8 weeks at 25 C. Eggs are laid in a gelatinous matrix by the female on the roots of citrus; the duration of egg incubation ranges from 12 to 14 days. The nematodes

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Fig. 1. Scanning electron photomicrograph of the posterior portions of an adult citrus nematode female and juveniles invading a citrus root.

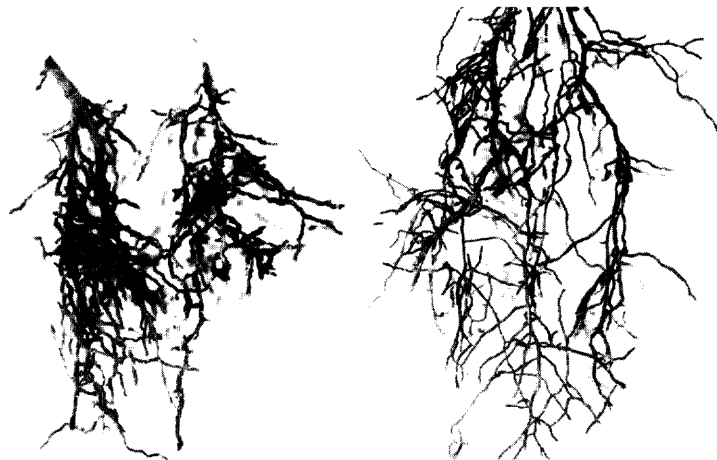


Fig. 2. Left, citrus roots heavily infested with citrus nematodes. Soil particles and root debris adhere to a gelatinous matrix deposited on the root surface by egg laying female citrus nematodes. Right, roots from a tree to which nematode control measures were applied.

undergo four molts; the first occurring in the egg, and emerge as second-stage juveniles. Males neither feed on nor infect roots and complete their life cycle in 7 to 10 days. Only the female becomes embedded in the root where it feeds on the cortical cells and develops to maturity. About one-fourth of the anterior portion of the female body is within the root, usually 4 to 5 cells deep, but never beyond the cortex. After a feeding site is established, the nematode's body becomes immobile, with its posterior portion exterior to the root. This portion, outside the root, becomes greatly enlarged at maturity (Fig. 1).

Symptoms (root): Citrus nematodes do not cause galling or knots on the roots. Females exude a gelatinous matrix that serves to protect the nematode eggs. Soil particles adhering to this matrix cause the infected roots to appear to have increased diameters (Fig. 2). Actually, infected roots are slightly enlarged and have a very irregular surface irrespective of the adhering soil. The outer portion of such roots often separates readily from the axial portion, exposing the central cylinder.

Symptoms (aboveground): Not all citrus trees having a high citrus nematode population on the roots show aboveground symptoms. Symptom expression may not be noticeable for 5 to 10 years after peak nematode population levels are reached. However, aboveground symptoms, when they finally appear, consist of general symptoms of malnutrition, such as yellowing of leaves, sparse foliage, small, nonuniform fruit, and defoliated branch ends. Infected trees shed more leaves than do uninfected trees. This is particularly true during periods of environmental stress, such as those occurring in Florida during the low-rainfall season in the spring. The degree of decline may vary considerably from tree to tree. Generally, the correlation between nematode populations and decline symptoms is negative. Large populations of the parasite build up on the extensive roots of growing trees. These populations decrease rapidly as roots are damaged, become decayed, and decrease in number. Thus, trees in stages of decline may have lower populations of citrus nematodes than those with an abundance of roots on which the nematodes can feed. Under optimum conditions of cultivation, trees can live and produce with relative normality in spite of the presence of the nematode. However, if an imbalance between the below or above ground portion of a tree occurs, then the nematode becomes a factor which augments this imbalance. Eventually, trees decline, due to a deteriorated root system, resulting in a reduction in fruit yield and quality.

Nematode control: Trees planted in old grove sites which were previously infested with the citrus nematode often show symptoms of slow decline earlier than infected trees planted in clean soil. To avoid this problem old grove sites should be treated with a soil fumigant before trees are transplanted. Conventional chisel-fumigation equipment is used for application of the soil fumigant. The material may be applied broadcast over the total area or depending on row spacing on proportionately less of the total area, making certain to treat a minimum of approximately 2 meters to either side of the row middle. 1,3-D (1,3-dichloropropene and related chlorinated C3 hydrocarbons) is the registered soil fumigant now in use.

Nonfumigant nematicides are presently being used on established citrus in many areas of the world. Aldicarb, 2-methyl-2-(methylthio) propionaldehyde O (methylcarbomoyl) oxime, and fenamiphos, ethyl 3-methyl-4-(methylthio) phenyl (1-methylethyl) phosphoramidate are non-fumigant nematicides federally registered for use on citrus in the U.S. However, state regulations may provide for different patterns of use than are encompassed in the federal label in some states. Therefore, before treating citrus, check with state authorities for specific local regulations and requirements before application of any nematicides.

Aldicarb and fenamiphos are taken up by plants and may be systemically distributed. In addition to nematodes, they also control mites and insects. Most nonfumigants are water soluble and rely on water to move them through the soil profile. They are applied to the soil surface or incorporated two to five cm below the soil surface as granular or liquid formulations just under the skirt of the tree. In general, the nonfumigant nematicides are not as effective as soil fumigants but they are easier to apply.

Treating a reset site in a grove before transplanting a new tree can also be accomplished by basin application or chisel injection of chemicals to the site. Site treatment, using an injector-probe that releases methyl bromide into the soil at one spot where it diffuses into the surrounding soil to a radius of at least 1.5 meters, has given effective nematode control. Other materials available for use where registered are metham sodium, sodium methyldithiocarbamate, and a mixture of methylisothiocyanate/1,3-dichloropropene and related chlorinated C3 hydrocarbons. Preplant treatment will aid a tree in becoming established; however, a few nematodes will manage to survive. In time nematode populations increase, requiring additional treatment after several years.

Rootstock reaction: There are many reports of citrus nematode resistant rootstocks worldwide. In the U.S. trifoliolate orange and other plants botanically close to citrus are highly resistant or immune to the citrus nematode. Several selections of Poncirus trifoliata have shown a high degree of resistance. Swingle citrumelo has been identified as resistant and is being developed commercially. However, none of the above rootstocks are suitable for all citrus growing areas of the U.S. and citrus nematode biotypes have been found in various states that reproduce differently on these resistant rootstocks. Therefore, there is still a need for development of rootstocks that are nematode, disease and insect resistant. Two biotypes once identified as citrus nematodes are found on monocots and dicots in Florida. These biotypes do not attack citrus, and recent studies indicate they are different species from Tylenchulus semipenetrans (3).

It is most important to start with seedlings that are free of all nematodes. With the development of container grown nursery stock that is nematode free, and stringent sanitation programs, many problems can be avoided. However, these young trees must be planted in groves that have been properly treated for nematodes or in sites that have no previous history of citrus.

Crop response: Estimates of losses have been attained by measuring yield increases as a result of disease elimination through successful nematode control, and by comparing the performance of infected trees with that of uninfected trees. Data available on yield increases from citrus nematode control in various citrus-growing countries suggest a world average range of 20 to 30% increase in citrus yield. Because all infected citrus trees are not economically damaged by this nematode, crop loss estimates on a worldwide basis due to the citrus nematode have been estimated to be between 8.7 and 12.2% (2).

LITERATURE CITED:

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